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U.S. DEPARTMENT OF COMMERCE
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# Commercial Fishery and Biology of the Fresh-Water Shrimp, *Macrobrachium*, in the Lower St. Paul River, Liberia, 1952-53

SPECIAL SCIENTIFIC REPORT–FISHERIES No. 626

## NOTE

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
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By

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# Commercial Fishery and Biology of the Fresh-Water Shrimp, *Macrobrachium*, in the Lower St. Paul River, Liberia, 1952-53

By

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## ABSTRACT

A small fishery was conducted for the large commercial fresh-water shrimp, *Macrobrachium vollenhovenii*, using traps. A second smaller species, *M. macrobrachion*, was culled from the trap catch for the fishermen's use. The estuarine fishery was seasonal (May to January), during the period of low salinity. Cost of raw tail meats to the consumer was over $1.00 (U.S.) per pound. The fishermen derived more than $7,500 from the fishery.

Commercial shrimp, *M. vollenhovenii*, spawned in the estuary from May to January. Fecundity was estimated at 12,000 to 45,000 eggs per female. As the embryo developed the color of the egg changed from red to brown. Embryonic and larval development to time of setting of *M. vollenhovenii* was believed similar to that of *M. rosenbergii*, 50 to 65 days. An intensive push-net fishery was conducted by women on the zero age group soon after the juveniles had set. Juvenile shrimp were not caught by traps. Monthly length distributions indicated that the fishery was supported by age group one, which was replaced at the end of the season by age group zero. Age group zero grew rapidly and reached a modal length of 75 to 80 mm. in 9 months in January; and adults grew slowly and increased in length to 85 to 90 mm. in May, and 100 to 105 mm. in November. The weight-length relation of *M. vollenhovenii* ovigerous females was expressed by the equation Log W = —4.656603 + 3.011392 Log L, and males and nonovigerous females by Log W = —4.829560 + 3.092213 Log L.

The characters used to distinguish *M. macrobrachion* from the commercial shrimp are given. The smaller species (modal length 50 to 54 mm.), constituted 88 percent of the shrimp discarded from the commercial catch. The trap fishery harvested the adults of the two species, which differed considerably in length, without harm to either species.

## INTRODUCTION

Fresh-water shrimp, *Macrobrachium* (family Palaemonidae), are found worldwide in tropical fresh and brackish waters. Commercial fisheries exist for many of the species (Holthuis and Rosa, 1965). Interest has been shown in the possibility of using fresh-water shrimp for aquaculture because of their fast growth rate (Dobkin, 1967; Ling, 1967a, 1967b; Ling and Merican 1962; and Williamson, 1967). Publications on the fresh-water shrimp indigenous to West Africa consist primarily of systematic studies.

A seasonal commercial fishery exists for fresh-water shrimp (known locally as crawfish), in the lower St. Paul River near Monrovia, Liberia, West Africa (fig. 1). In 1952-53, I made a general survey of the fishery and

[1] The author made this study while on loan from the U.S. Fish and Wildlife Service to the U.S. Foreign Operations Administration, as Technical Advisor in Marine Fisheries to the Liberian Government.

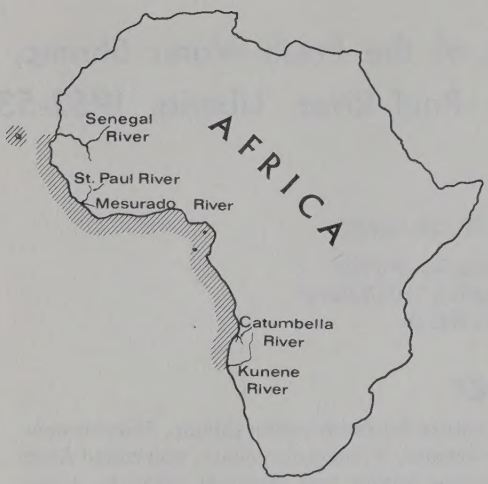


Figure 1.—Distribution and some geographical locations of the commercial shrimp, *M. vollenhovenii*, in Africa.

a study of the biology of the commercial species. Because my primary responsibility in Liberia was as the Adviser in Marine Fisheries, my study was a secondary project limited by a lack of time.

The commercial catch in the lower St. Paul River is composed of two species: *Macrobrachium vollenhovenii* (Herklots), a large commercial shrimp; and *Macrobrachium macrobrachion* (Herklots), a small shrimp culled from the catch and eaten by the fishermen. Both species are of commercial importance in Dahomey (Monod, 1966). The present report is concerned primarily with the large commercial fresh-water shrimp, *M. vollenhovenii*.

## METHODS AND MEASUREMENTS

I obtained samples from the commercial fishery at least once a month during the season. Traps used, were tightly woven, and prevented the escapement of small shrimp. The tiny shrimp of the incoming year class were obtained from fishermen who collected them in burlap push-nets. Total length, from the base of the eyestalk to the tip of the telson, was measured to the nearest millimeter with a simple measuring board (Pruter and Harry, 1952). Shrimp were weighed on a Harvard Trip Balance after the major chelipeds had been removed. Specimens 60 mm. long or longer were weighed to the nearest gram; those less than 60 mm. were weighed to the nearest 0.1 g. Salinity samples were taken at stations in the estuaries within 1.6 km. (1 mile) of the mouths of the Mesurado and St. Paul Rivers.

## COMMERCIAL FISHERY

The commercial fishery for fresh-water shrimp is insignificant compared with the catch and value of other fisheries, but it is significant to the economy of the people of the lower St. Paul River. The fishery for fresh-water shrimp in the lower St. Paul River will be described and the economic value of the fishery estimated.

### Location

In Monrovia, fresh-water shrimp sold were captured within 3.2 km. (2 miles) upstream from the mouth of the St. Paul River. (The headwaters of the St. Paul River rise in the highlands of Guinea, north of Liberia.) The shoreline, composed of rock-gravel substrate, varied from gradual to steep. Outcrops of large rocks were present along the shore and in the channel (fig. 2). Fishing was carried out within the tidal zone.

### Description of the Fishery

Traps used in the fishery were made of 6 to 13 mm. (¼-½ in.) wide strips peeled from the hard outer layer of a palm frond stem. The strips were tightly interlaced into a fusiform trap, 101 to 152 mm. (4-6 in.) in diameter at the large end and 457 mm. (18 in.) long (fig. 3). The wide end of the trap had an involuted opening 38 to 51 mm. (1½-2 in.) in diameter, followed (within the trap) by a second fyke opening of the same size.

The bait most commonly used was the white core of the cassava root, *Manihot utilissima*. Three or four 19-mm. (¾-in.) square pieces were placed in each trap. When the tide was low, the traps were placed in the intertidal area and partially covered by large rocks; the catch (up to 36 large shrimp per trap) was removed on the next low tide (fig. 4). Shrimp were sorted by removing the small ones for

Figure 2.—Liberian woman lifting traps placed near rock outcrop by fishermen lower St. Paul River, Liberia, downstream from the William V. S. Tubman bridge.

the fisherman's consumption and either selling the large ones immediately or holding them for the customary Saturday market. When shrimp were kept in holding traps in the river, the large chelipeds were removed to prevent cannibalism. At the peak of the season, a fisherman's catch was often as high as 120 dozen large shrimp per week.

The fishermen's catch depended upon the stage of the river. During periods of heavy precipitation, the river flooded and the fishermen were unable to retrieve their traps.

In the lower St. Paul River the fishery was directly correlated with the rainy season, May to November (Orton, 1954) and the runoff lag of the river to January (table 1). The estuarine water during the rainy season was turbid and fresh. During the dry season, February to May, the estuarine water was clear, highly saline, and the shrimp fishery was nonexistent.

Table 1.—Comparison of salinities (parts per thousand) in the lower St. Paul and Mesurado Rivers, Liberia estuaries, November-December 1953

| Date 1953 | St. Paul River | Mesurado River |
|---|---|---|
| | *P.p.t.* | *P.p.t.* |
| Nov. 2 | 0.0 | 18.0 |
| Nov. 9 | 0.7 | 9.2 |
| Nov. 16 | 0.8 | 16.3 |
| Nov. 23 | 0.5 | 31.0 |
| Nov. 30 | 0.9 | 20.0 |
| Dec. 7 | 1.8 | 34.4 |
| Dec. 14 | 1.2 | 23.0 |

Figure 3.—Construction of fresh-water shrimp traps in the lower St. Paul River, Liberia.

The small, mangrove-type Mesurado River, which adjoins the St. Paul River, lacks the runoff lag and becomes highly saline several months before the St. Paul River (table 1). The higher salinities and lack of rock bottom habitat are believed to be the primary reasons for the negligible numbers of fresh-water shrimp caught in the Mesurado River estuary.

The oceanic waters of the Monrovia Freeport were directly influenced by the low salinity runoffs of the St. Paul and Mesurado Rivers. The Monrovia Freeport is located intermediate, and a short distance between the two rivers. The runoff lag of the St. Paul River as it decreased in December-January was reflected by increased salinities in the Freeport (table 2).

## Economic Value

The economic value of the shrimp varied with size. At the beginning and end of the season, when shrimp were small, 18 shrimp retailed for 25 cents (U.S.) to the consumer. During the rest of the season, the fishermen

Table 2.—Salinities in the Monrovia Freeport, Liberia, August 1953-January 1954

| Month | Lowest salinity | Highest salinity | Average salinity |
|---|---|---|---|
| | *P.p.t.* | *P.p.t.* | *P.p.t.* |
| Aug. | 11.0 | 24.0 | 17.1 |
| Sep. | 6.2 | 24.4 | 12.7 |
| Oct. | 5.2 | 23.5 | 13.7 |
| Nov. | 18.2 | 30.4 | 25.2 |
| Dec. | 23.8 | 32.8 | 30.0 |
| Jan. | 28.8 | 33.3 | 31.5 |

Figure 4.—Liberian woman tending shrimp traps set in the tidal zone on a rock-gravel substratum in the lower St. Paul River, Liberia.

received 25 cents per dozen. The number of whole shrimp per pound varied from 17 to 37 (table 3). The tail (abdomen) weight accounted for 51 to 53 percent of the body weight, and the recovery of cooked and shucked tail meat was 21 percent of the body weight. The cost per pound of whole shrimp when purchased by the dozen varied from 55 to 64 cents. The price of shucked, cooked tail meats to the consumer, at 25 cents per dozen live shrimp, varied from $2.63 to $3.01 per pound in June.

The value of the shrimp fishery in the lower St. Paul River was estimated. I was not able to gather total catch statistics because of the erratic method of marketing and the varying number of fishermen and traps fished. In July 1952, 12 fishermen were known to be shrimp fishing in the lower St. Paul; conservative estimates were that 16 additional fishermen participated. The entire catch by 4 fishermen in July was 481 dozen shrimp, worth $120.25. If their catches can be considered average, the estimated catch in July by the 28 fishermen was 3,367 dozen, worth $841.75. Because I considered July to be an average month, the value of the fishery during the 9-month fishing season probably exceeded $7,500.

## BIOLOGY OF *M. vollenhovenii*

The biology *M. vollenhovenii* includes the distribution, description, length-frequency

Table 3.—Total weights and weights of head (cephalothorax) and tail (abdomen) of *M. vollenhovenii* caught commercially in the lower St. Paul River, Liberia, June to December 1953

| Date 1953 | Shrimp | Body weight | Head | | Tail | | Average weight of shrimp | Shrimp per lb. |
|---|---|---|---|---|---|---|---|---|
| | | | Weight | % total body weight | Weight | % total body weight | | |
| | *No.* | *G.* | *G.* | *%* | *G.* | *%* | *G.* | *No.* |
| June 13 | 341 | 4,180 | 2,017 | 48.25 | 2,163 | 51.75 | 12.26 | 37.00 |
| June 20 | 499 | 8,414 | 4,101 | 48.74 | 4,313 | 51.26 | 16.86 | 26.90 |
| Aug. 28 | 86 | 1,662 | 813 | 48.92 | 849 | 51.08 | 19.33 | 23.47 |
| Sept. 4 | 59 | 1,411 | 694 | 49.18 | 717 | 50.82 | 23.92 | 18.96 |
| Sept. 11 | 50 | 877 | 411 | 46.86 | 466 | 53.14 | 17.54 | 25.86 |
| Oct. 2 | 33 | -- | -- | -- | -- | -- | 12.79 | 35.47 |
| Oct. 16 | 167 | -- | -- | -- | -- | -- | 22.91 | 19.80 |
| Nov. 13 | 360 | -- | -- | -- | -- | -- | 26.46 | 17.14 |
| Nov. 27 | 708 | -- | -- | -- | -- | -- | 24.99 | 18.15 |
| Dec. 4 | 874 | -- | -- | -- | -- | -- | 20.96 | 21.64 |

distributions of the catch, weight-length relation, fecundity and spawning, and disease.

## Distribution

*M. vollenhovenii* was described by Herklots (1857) from specimens collected by H. Pel in "Côte de Guinée." Holthuis (1951) believed that the type locality was erroneous because Pel had collected only in the Gold Coast (now Ghana). Holthuis listed the synonymy of *M. vollenhovenii* and gave its distribution as the offshore islands of Cape Verde, Fernando Po, and Sao Thomé, and from Senegal south along the West African coast to the Kunene River in southern Angola.

## Description

*M. vollenhovenii* grows to a total length of more than 150 mm. In life the body is gray or brown with a blue lateral line on the abdomen; a blue lateral line extends from midway on the carapace forward and bifurcates with a ventral branch to the hepatic spine and dorsal branch over the orbit to the tip of the rostrum. The rostrum is short, deep, and slightly upturned at the tip; the dorsal surface bears 11 to 15 spines and the ventral surface 3 to 8; though the spines may or may not extend to the tip of the rostrum, each spine is preceded by setae — in many specimens setae are found near the anterior end of the rostrum where no spines are present. The carpus of the major chela is always shorter than the palm, and the fingers are not pubescent. In early stages of development the external eggs of the female are orange to red, but change to brown in the advanced stage before hatching.

Rostral spine counts have been used to distinguish species of *Macrobrachium*. To determine variation in numbers of rostral spines, I made counts from 218 specimens of *M. vollenhovenii* taken from the lower St. Paul River on October 9, October 13, and November 13, 1953. I then compared the rostral spine counts of shrimp from the St. Paul River, Liberia, with those given by Man (1904) of shrimp from the Catumbella River, Angola, to discover whether the populations differed between the two widely separated areas (table 4).

The number of dorsal rostral spines on *M. vollenhovenii* ranged from 11 to 15, with one exception (18) given by Man (1904). Modally the St. Paul River shrimp had 13 dorsal rostral spines and Catumbella River specimens had 12. The small difference in counts was probably caused by a difference in the sizes of specimens (my specimens were larger than Man's) rather than a genetic or clinical difference between the two populations of *M. vollenhovenii*. Ventral rostral spines varied from three to eight, but both populations had four modally.

## Length-Frequency Distribution

The commercial fishery was sampled for length distributions of the catch from July to January (1952 season) and from May to November (1953 season). Figure 5 shows the length distributions of 7,648 commercial shrimp

Table 4.—Comparison of rostral spine counts of *M. vollenhovenii* from the lower St. Paul River, Liberia, and the Catumbella River, Angola

| Number of spines | St. Paul River | | Catumbella River (from Man, 1904) | |
|---|---|---|---|---|
| | Shrimp | % of total examined | Shrimp | % of total examined |
| | *No.* | *Percent* | *No.* | *Percent* |
| Dorsal-ventral: | | | | |
| 11-3 | 2 | 0.9 | 0 | 0.0 |
| 12-3 | 23 | 10.6 | 11 | 25.0 |
| 13-3 | 11 | 5.1 | 2 | 4.5 |
| 14-3 | 3 | 1.4 | 1 | 2.3 |
| 11-4 | 4 | 1.8 | 1 | 2.3 |
| 12-4 | 41 | 18.8 | 12 | 27.3 |
| 13-4 | 61 | 28.0 | 7 | 15.9 |
| 14-4 | 30 | 13.8 | 5 | 11.4 |
| 15-4 | 3 | 1.4 | 1 | 2.3 |
| 12-5 | 4 | 1.8 | 0 | 0.0 |
| 13-5 | 10 | 4.6 | 1 | 2.3 |
| 14-5 | 16 | 7.3 | 0 | 0.0 |
| 15-5 | 6 | 2.8 | 0 | 0.0 |
| — | — | — | — | — |
| — | — | — | — | — |
| 18-5 | 0 | 0.0 | 1 | 2.3 |
| 12-6 | 1 | 0.5 | 1 | 2.3 |
| 13-6 | 0 | 0.0 | 0 | 0.0 |
| 14-6 | 0 | 0.0 | 1 | 2.3 |
| 15-6 | 1 | 0.5 | 0 | 0.0 |
| 13-7 | 1 | 0.5 | 0 | 0.0 |
| 13-8 | 1 | 0.5 | 0 | 0.0 |
| Dorsal: | | | | |
| 11 | 6 | 2.8 | 1 | 2.3 |
| 12 | 69 | 31.7 | 24 | 54.5 |
| 13 | 84 | 38.5 | 10 | 22.7 |
| 14 | 49 | 22.5 | 7 | 15.9 |
| 15 | 10 | 4.6 | 1 | 2.3 |
| — | — | — | — | — |
| — | — | — | — | — |
| 18 | 0 | 0.0 | 1 | 2.3 |
| Ventral: | | | | |
| 3 | 39 | 17.9 | 14 | 31.8 |
| 4 | 139 | 63.8 | 26 | 59.1 |
| 5 | 36 | 16.5 | 2 | 4.5 |
| 6 | 2 | 0.9 | 2 | 4.5 |
| 7 | 1 | 0.5 | 0 | 0.0 |
| 8 | 1 | 0.5 | 0 | 0.0 |

I sampled in the 1952 and 1953 seasons, grouped monthly in 5-mm. intervals.

The trap catch was selective: few juveniles were caught before they reached the minimum size of maturity (45-50 mm.). Trap selectivity was possibly due to a dietary difference between the juveniles and adults. I found a similar selectivity in the trap catch for the western North American fresh-water crawfish, *Pacifastacus leniusculus* (Dana) (Miller, 1960).

Knowledge of the shrimps' biology and the length distributions of the catch led me to speculate that the commercial fishery was supported primarily by a single age group. Female shrimp with eggs in advanced stage of development were found from May to January, which would explain the wide range of the length distributions (fig. 5).

The modal length increased each month through November during the commercial seasons (May to January) of 1952 and 1953. In the 1952 season, the modal length declined in December and January (no data for these months in the 1953 season). This type of distribution indicates that the fishery was supported by a single age group, which was replaced late in the season by the incoming zero age group. Growth rate was rapid, and age group zero reached a modal length of 75 to 80 mm. in 9 months. Growth of the mature shrimp was slow — the shrimp reached a modal length of 75 to 80 mm. in January, 85 to 90 mm. in May, and 100 to 105 mm. in November.

The rapid growth of juveniles, and slow growth of adults given for *M. vollenhovenii* is similar to the growth rate of *M. rosenbergii* reported by Ling (1967a). The females and males of *M. rosenbergii* reached a length of 140 mm. in 5½ months, and the females grew only slightly beyond 150 mm.; the male growth, however, continued to 200 mm.

Two other possible explanations for the length distributions were examined and then rejected: (1) the unimodal distribution consisted of more than two age groups, the same as other trap caught crustaceans; and (2) the large shrimp, being less salinity tolerant than small shrimp, were the last to enter the estuary at the beginning of the season and the first to leave the estuary at the end of the season.

The first explanation was rejected because the modal length increased each month. I found in trap-caught western North American fresh-water crawfish, *Pacifastacus* Bott, that aging by length distributions was nearly

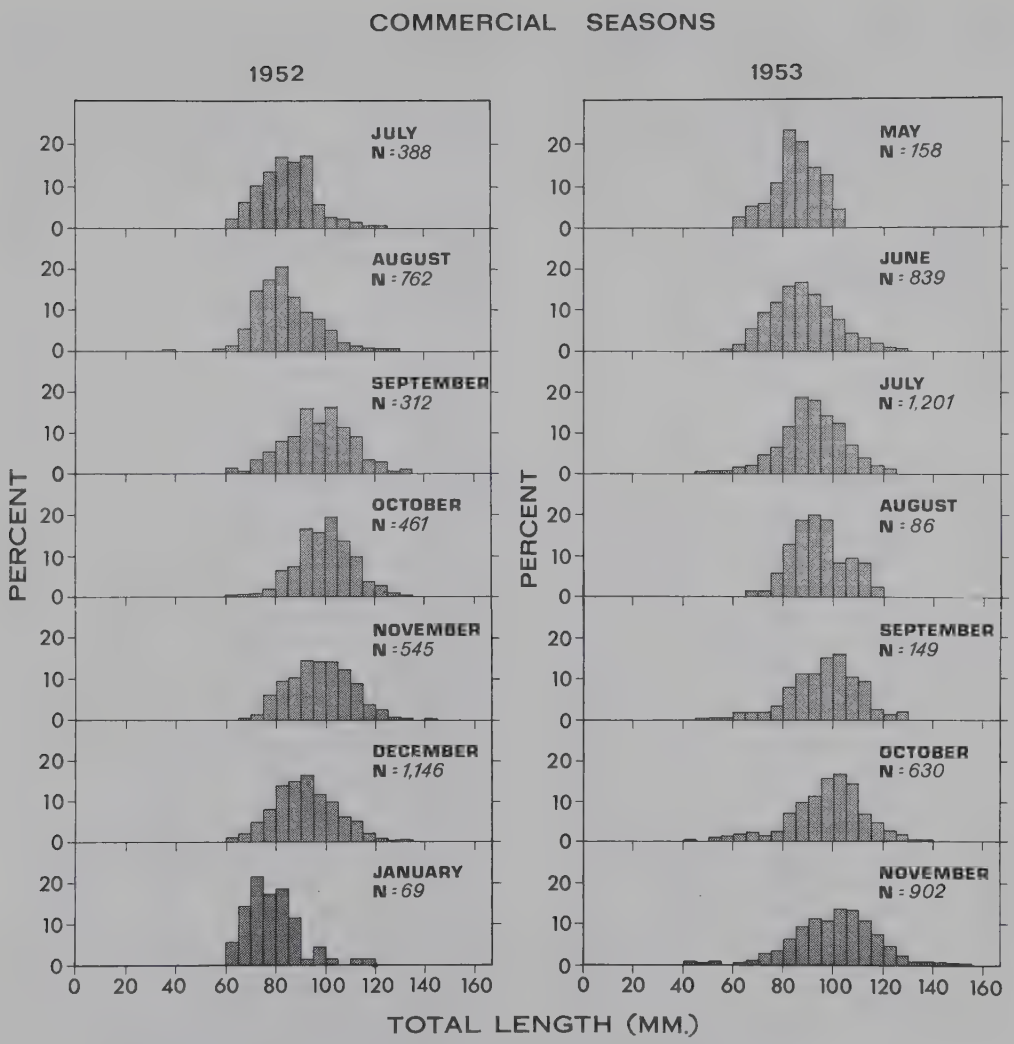


Figure 5.—Monthly length distributions of commercially caught shrimp, *M. vollenhovenii*, from the lower St. Paul River, Liberia.

impossible because of overlapping age groups (Miller, 1960). Length distributions of the western crawfish plotted by month was nearly identical because: recruitment in each size interval was relatively proportionate following a molt; there was little variance in growth increment of the same length crawfish; there was no identifiable modal length increase by month; and growth in the adults was a function of food availability, not age.

The second explanation was rejected because I could see no evidence in the length distributions to support the entrance of the large adults into the fishery in early summer (fig. 5). If age group one does not die off naturally in December but migrates upstream or into adjacent swampy areas, then I speculate that these shrimp, as age group two, survivors contribute very little to the population.

## Weight-Length Relation

The shrimp were separated into two categories — (1) ovigerous females and (2) males and nonovigerous females combined. I had insufficient time to determine the sex of the nonegg bearing shrimp. Live shrimp (major chelae removed) were measured and weighed. I made no attempt to find the effect of the holding period on weight — any effect probably was insignificant, since the shrimp were fed by their keepers, and holding did not diminish the shrimps' voracious cannibalistic appetite.

If fewer than 100 shrimp were weighed and measured in any monthly sample, I used the entire sample in my calculations; if more than 100 were weighed and measured, only 100 were used. The weight-length relation of 100 shrimp was derived from the 15 shortest, the 15 longest, and 70 shrimp taken at random from the sample. The weight-length relation is described by the equation Log W = Log a + b Log L, which is the logarithmic transformation of $W = aL^b$, where W = weight in grams and L = body length in millimeters.

The weight-length relations by month (table 5) were plotted on logarithmic paper, but differences were small. Samples were then grouped to derive the relation between weights and lengths for the ovigerous females and for the combined males and nonovigerous females. Ovigerous females were slightly heavier than males and nonovigerous females (fig. 6).

Table 5.—Weight-length relation of *M. vollenhovenii* caught in Liberia, 1952-53

| Date | Shrimp examined | b | Log a (−) |
|---|---|---|---|
| | *No.* | | |
| Males and nonovigerous females: | | | |
| December 1952 . | 100 | 3.233760 | 5.104878 |
| January 1953 .. | 69 | 3.103854 | 4.900119 |
| February, March, and April 1953 | — | — | — |
| May 1953 ..... | 100 | 2.888036 | 4.430167 |
| June 1953 ..... | 100 | 2.942819 | 4.528751 |
| July 1953 ..... | 100 | 2.923373 | 4.488341 |
| August 1953 ... | 80 | 3.009451 | 4.668415 |
| September 1953 | 100 | 3.204240 | 5.059211 |
| October 1953 ... | 100 | 3.077283 | 4.791176 |
| November 1953 . | 100 | 3.069324 | 4.750091 |
| December 1953 . | 62 | 3.229206 | 5.099838 |
| Total ..... | 911 | 3.093213 | 4.829690 |
| Ovigerous females: 1952-53 ..... | 181 | 3.011392 | 4.656069 |

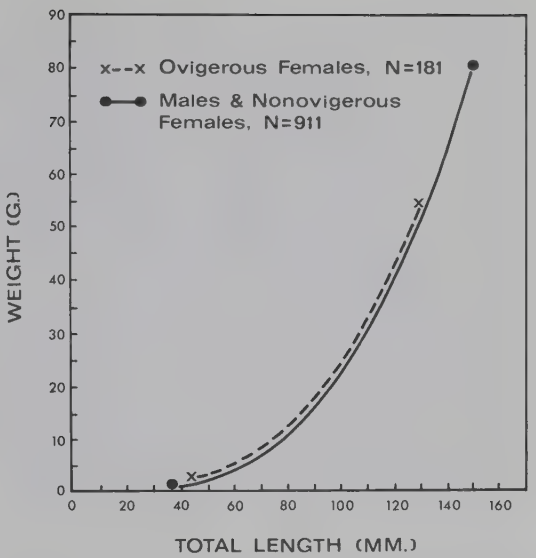


Figure 6.—Weight-length relation of commercial shrimp, *M. vollenhovenii*, for ovigerous females (range 47-131 mm., Log W = −4.656603 + 3.011392 Log L) and males and nonovigerous females (range 39-150 mm., Log W = −4.829560 + 3.092213 Log L). Shrimp were captured in the lower St. Paul River, Liberia, 1952-53.

Only a slight difference was seen between the weight-length relation of *M. vollenhovenii* and the weight-length data of pond-cultured *M. rosenbergii* given by Ling (1967a). The growth differential between the two species is exceedingly different — *M. rosenbergii* reached 155 m. in 7 months.

## Fecundity and Spawning

I estimated the fecundity by counting the number of eggs that displaced a known volume of water. Because the fecundity of crustaceans differs with size, the sample was selective in that small shrimp (76-82 mm.) and large shrimp (101-113 mm.) were used to estimate numbers of eggs per female. In small shrimp 1,555 to 1,785 eggs displaced 0.1 ml. of water; in large shrimp 850 eggs displaced 0.1 ml. of water. Estimates of the numbers of eggs carried externally by the small shrimp

varied from 12,885 to 34,210 and by the large shrimp from 37,550 to 45,000.

Ovigerous females were taken in the lower St. Paul River throughout the May-January fishery. The lengths of the ovigerous females ranged from 47 to 131 mm. and the mode was in the 80- to 90-mm. interval (fig. 7). Of the total number of ovigerous females, shrimp less than 60 mm. made up 2.5 percent, and shrimp greater than 115 mm. made up 2.7 percent of the catch. The higher percentage of females bearing advanced (brown and eyed) eggs occurred in the same months as the higher percentages of females bearing less developed (red) eggs (table 6). This would indicate an embryonic period of less than 1 month. Ling (1967a) found the embryonic period in *Macrobrachium rosenbergii* was 19 to 20 days at 26 to 28° C.

Peak spawning periods occurred during the commercial seasons—in 1952, *M. vollenhovenii* spawned in August and December, and in 1953, in September and December (table 6). Rajyalakshmi and Randhir (1967), reported that in India the commercial prawn, *Macrobrachium malcolmsonii* (Edwards), has two spawning peaks. No explanation can be given for the smaller percentage of ovigerous females of *M. vollenhovenii* found in the 1952 catch than in that of 1953 (table 6).

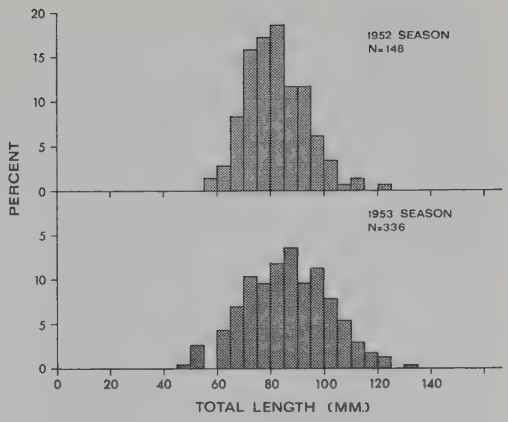


Figure 7.—Length distributions of ovigerous female shrimp, *M. vollenhovenii*, in the commercial catch, during the 1952-53 season, in the lower St. Paul River, Liberia.

The zero age group was subjected to an intensive fishery soon after it appeared. Groups of 3 to 10 women drove large push-nets made of burlap sacking along the shore and

Table 6.—Numbers and percentages of *M. vollenhovenii* females with eggs in the early (red) and late (brown) stages of development, and total number of ovigerous females during the 1952 and 1953 commercial seasons, in Liberia

| Month | Shrimp | Females with red eggs | | Females with brown eggs | | Total ovigerous females | |
|---|---|---|---|---|---|---|---|
| | *Number* | *Number* | *Percent* | *Number* | *Percent* | *Number* | *Percent* |
| 1952 season: | | | | | | | |
| July | 388 | 13 | 3.4 | 9 | 2.3 | 22 | 5.7 |
| August | 762 | 35 | 4.6 | 27 | 3.5 | 62 | 8.1 |
| September | 312 | 1 | 0.3 | 1 | 0.3 | 2 | 0.6 |
| October | 461 | 12 | 2.6 | 3 | 0.7 | 15 | 3.3 |
| November | 545 | 7 | 1.3 | 1 | 0.2 | 8 | 1.5 |
| December | 678 | 17 | 2.5 | 20 | 2.9 | 37 | 5.4 |
| January | 69 | 0 | 0.0 | 2 | 2.9 | 2 | 2.9 |
| Total | 3,215 | 85 | 2.6 | 63 | 2.0 | 148 | 4.6 |
| 1953 season: | | | | | | | |
| May | 158 | 4 | 2.5 | 7 | 4.4 | 11 | 6.9 |
| June | 839 | 8 | 1.0 | 1 | 0.1 | 9 | 1.1 |
| July | 1,201 | 47 | 3.9 | 21 | 1.7 | 68 | 5.6 |
| August | 86 | 2 | 2.3 | 4 | 4.6 | 6 | 6.9 |
| September | 149 | 22 | 14.7 | 10 | 6.7 | 32 | 21.4 |
| October | 630 | 41 | 6.5 | 8 | 1.3 | 49 | 7.8 |
| November | 935 | 35 | 3.7 | 22 | 2.4 | 57 | 6.1 |
| December | 874 | 55 | 6.3 | 49 | 5.6 | 104 | 11.9 |
| Total | 4,872 | 214 | 4.4 | 122 | 2.5 | 336 | 6.9 |

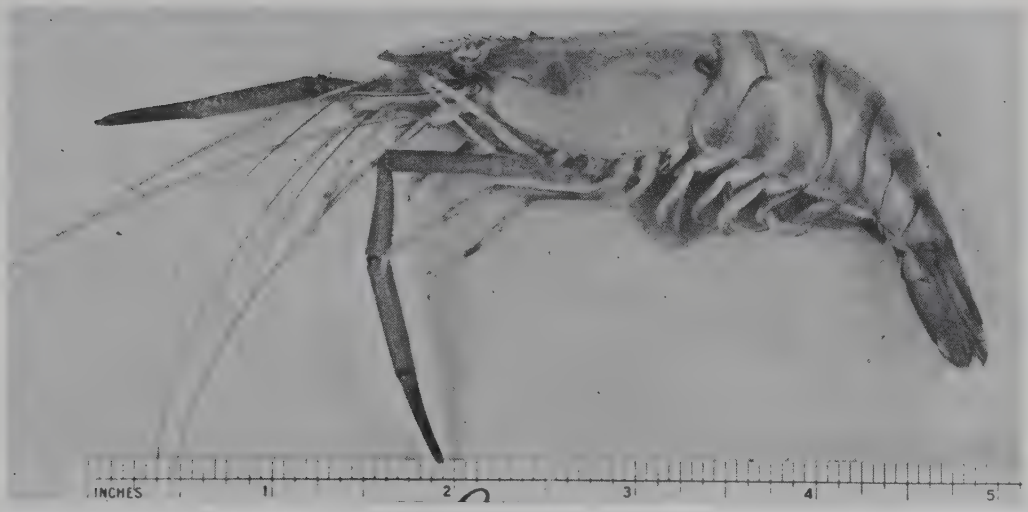


Figure 8.—Lateral view of the commercial shrimp, *M. vollenhovenii*, with black-spot disease on the carapace, abdomen, and walking legs.

caught countless numbers of young shrimp and larval fishes. The catch, molded into cakes and placed between banana leaves, was smoked and eaten by the fishermen.

When I examined the catch made by the women on November 15, 1953, I found that the young shrimp averaged 5 to 10 mm. long. Before November juvenile shrimp were not abundant, an indication that the group caught in November was from the peak spawning in September. The early development of *M. vollenhovenii* appears to be nearly identical to that of *M. rosenbergii* reported by Ling (1967a). Ling (1967a) found embryonic development was 19 to 20 days, larval development (planktonic) 30 to 45 days, or a total of 50 to 65 days until the shrimp settled as 4.5- to 5.0-mm. juveniles.

### Disease

A black-spot microbial infection was found around scratches on the body or legs of shrimp (fig. 8). Anderson and Conroy (1968) have reported similar diseases in crustacea. The infection not only ate through the carapace or abdomen but also attacked underlying tissues such as the gill filaments or the abdominal muscles; the telson and walking legs also were heavily infected. At times, the infection formed a ring around the middle portion of a walking leg and caused part of the leg to fall off. Identification of the disease was not possible because laboratory facilities were lacking. A sample of 150 shrimp examined on May 30, 1953, had 137 infected. Though not confined to shrimp of any size range, the infection appeared to be most severe on large individuals. The palatability of the shrimp did not appear to be affected by the infection. A substantial mortality of *M. vollenhovenii* may occur at times from the disease.

## BIOLOGY OF *M. macrobrachion*

The biology of *M. macrobrachion*, in this report, will include only a description of the small noncommercial species, and its contribution in numbers and size in the culls from the commercial catch.

### Description

*M. macrobrachion*, a small species, is usually less than 75 mm. long. The body is a light blue-gray mottled with dark spots. The rostrum is long and slender, and arches slightly upward at the tip; 8 to 10 dorsal spines extend from the carapace onto the rostrum, and a short space separates them from 2 spines at the tip of the rostrum; 4 to 6 spines are present on the ventral surface. The carpus of the

major chela is always as long or longer than the palm; the fingers are pubescent. The external eggs of the female, in early stages of development, are green but turn to dark brown in the advanced, eyed stage.

## Species and Size Composition of Culls from the Commercial Catch

I examined 221 shrimp 42 to 77 mm. long (discarded as too small to sell) on August 4, 1952, for species and size composition (table 7). The bulk of the sample was *M. macrobrachion* (88 percent) while the commercial shrimp *M. vollenhovenii* made up the remaining portion (12 percent). Less than 5 percent of the specimens of *M. vollenhovenii* were under 65 mm. long, whereas only 7 percent of the specimens of *M. macrobrachion* were larger than 65 mm. *M. macrobrachion* ovigerous females were numerous and constituted 33 percent of the sample, which was a much higher percentage than that of *M. vollenhovenii* at 0.5 percent. The ovigerous females of *M. macrobrachion* were 46 to 61 mm. long, and 59 percent of them were in the 50- to 54-mm. size interval. The nonovigerous females were 42 to 72 mm. long; 29 percent were in the 55- to 59-mm. size interval. The size range of *M. macrobrachion* in the sample was similar to that listed by Holthuis (1951) for specimens from Nigeria.

Throughout the investigation, *M. macrobrachion* was predominant among culls from the commercial fishery. The commercial fishery harvested the adults of both species, with no apparent detriment to either species.

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Table 7.—Length distribution and percentage of 221 shrimp, *Macrobrachium vollenhovenii* and *M. macrobrachion*, culled from the commercial catch in the lower St. Paul River, Liberia, August 4, 1952

| Species and total length (5-mm. intervals) | Male and female, without eggs | | Females with green or red eggs[1] | | Females with brown eggs | | Total ovigerous females | | Total shrimp examined | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *%* | *No.* | *%* | *No.* | *%* | *No.* | *%* | *No.* | *%* |
| *M. macrobrachion*: | | | | | | | | | | |
| 40-44 ..... | 2 | 0.9 | — | — | — | — | — | — | 2 | 0.9 |
| 45-49 ..... | 12 | 5.4 | 7 | 3.2 | 2 | 0.9 | 9 | 3.2 | 21 | 9.5 |
| 50-54 ..... | 31 | 14.0 | 27 | 12.2 | 16 | 7.2 | 43 | 19.5 | 74 | 33.5 |
| 55-59 ..... | 35 | 15.8 | 10 | 4.5 | 10 | 4.5 | 20 | 9.1 | 55 | 24.9 |
| 60-64 ..... | 27 | 12.2 | 1 | 0.4 | — | — | 1 | 0.5 | 28 | 12.7 |
| 65-69 ..... | 10 | 4.5 | — | — | — | — | — | — | 10 | 4.5 |
| 70-74 ..... | 5 | 2.3 | — | — | — | — | — | — | 5 | 2.3 |
| Total ..... | 122 | 55.1 | 45 | 20.3 | 28 | 12.6 | 73 | 32.3 | 195 | 88.3 |
| *M. vollenhovenii*: | | | | | | | | | | |
| 50-54 ..... | 1 | 0.4 | — | — | — | — | — | — | 1 | 0.5 |
| 55-59 ..... | 4 | 1.8 | — | — | — | — | — | — | 4 | 1.8 |
| 60-64 ..... | 5 | 2.3 | — | — | — | — | — | — | 5 | 2.3 |
| 65-69 ..... | 6 | 2.7 | — | — | — | — | — | — | 6 | 2.7 |
| 70-74 ..... | 8 | 3.6 | — | — | — | — | — | — | 8 | 3.6 |
| 75-79 ..... | 1 | 0.4 | — | — | 1 | 0.5 | 1 | 0.5 | 2 | 0.9 |
| Total ..... | 25 | 11.2 | — | — | 1 | 0.5 | 1 | 0.5 | 26 | 11.8 |

[1] Eggs in early stages of development are green in *M. macrobrachion* and red in *M. vollenhovenii*, while eggs in advanced stages of both species are brown.

Higgins, U.S. Fish and Wildlife Service; Lyle Calvin, Leonard Coleman, and Laurie Leonard, Oregon State University; and Max Katz, University of Washington.

## LITERATURE CITED

ANDERSON, J. I. W., and D. A. CONROY.
1968. The significance of disease in preliminary attempts to raise crustacea in sea water. Proc. IIIe Sympos. Comm. Off. Int. Épizoot. Étude Maladies Poissons, Separate 3, 8 pp.

DOBKIN, S.
1967. Abbreviated larval development in caridean shrimps and its significance in the artificial culture of these animals. FAO World Sci. Conf. on Biol. and Cult. of Shrimps and Prawns. Exp. Pap., Agenda item 8, FR: BCSP/67/E/53, 12 pp.

HERKLOTS, J. A.
1857. *Palaemon Vollenhovenii*, nouvelle espéce de Crustacé. Notices entomologiques. 2. Tijdschr. Ent. 1: 96-97.

HOLTHUIS, LIPKE B.
1951. The caridean Crustacea of tropical West Africa. Atlantide Rep. 2: 7-187.

HOLTHUIS, L. B., and H. ROSA JR.
1965. List of species of shrimps and prawns of economic value. FAO Fish. Tech. Pap. 52, 21 pp.

LING, S. W.
1967a. The general biology and development of *Macrobrachium rosenbergii* (de Man). FAO World Sci. Conf. on Biol. and Cult. of Shrimps and Prawns. Exp. Pap., Agenda item 3, FR: BCSP/67/E/30, 18 pp.
1967b. Methods of rearing and culturing *Macrobrachium rosenbergii* (de Man). FAO World Sci. Conf. on Biol. and Cult. of Shrimps and Prawns. Exp. Pap., Agenda item 8, FR: BCSP/67/E/31, 11 pp.

LING, S. W., and A. B. O. MERICAN.
1962. Notes on the life and habits of the adults and larval stages of *Macrobrachium rosenbergii* (De Man). Indo-Pac. Fish. Counc. Proc. 9th Sess., Sec. 2, 55-61.

MAN, J. G. DE.
1904. On some species of the genus *Palaemon* Fabr., from Tahiti, Shanghai, New Guinea, and West Africa. Trans. Linn. Soc. Lond. Zool., Ser. 2, 9: 291-327.

MILLER, GEORGE CARL.
1960. The taxonomy and certain biological aspects of the crayfish of Oregon and Washington. M.S. thesis, Oreg. Sta. Univ., Corvallis, Ore., 216 pp.

MONOD, THÉODORE.
1966. Crevettes et crabes de la côte occidentale d'Afrique. Réunion de Specialistes C.S.A. sur les Crustacés, Zanzibar 1964, Mém. Inst. Fond. Afr. Noire 77: 103-234 (issued 1967).

ORTON, CLAYTON R.
1954. Agriculture of Liberia. U.S. For. Op. Adm., Dept. Agric., For. Agric. Serv., 111 pp.

PRUTER, ALONZO T., and GEORGE Y. HARRY, JR.
1952. Results of preliminary shrimp exploration off the Oregon coast. Oreg. Fish. Comm., Res. Briefs 4(1): 12-24.

RAJYALAKSHMI, T., and M. RANDHIR.
1967. The commercial prawn *Macrobrachium malcolmsonii* (H. M. Edwards) of the river Godavary, a discussion on the trend and characteristics of the population during 1963-1966. FAO World Sci. Conf. on Cult. of Shrimps and Prawns, Mexico. Abstract, Agenda item 5, FR: BCSP/67/E/51.

WILLIAMSON, D. I.
1967. The type of development of prawns as a factor determining suitability for farming. FAO World Sci. Conf. on Biol. and Cult. of Shrimps and Prawns. Rev. Pap. Agenda item 8, FR: BCSP/67/R/1, 6 pp.

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